AGRICULTURALLY CONSISTENT MAPPING OF SMALLHOLDER FARMING SYSTEMS USING REMOTE SENSING AND SPATIO-TEMPORAL MODELLING

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PECORA 21 / ISRSE 38

cirad tetis TERRITOIRE ENVIRONNEMENT TÉLÉDÉTECTION INFORMATION SPATIALE cnes SPAD SYSTÈMES de PRODUCTION D'ALTITUDE ET DURABILITÉ MADAGASCAR #DigitAg

Context

- **Complex agricultural landscape, fragmented**
- **Small plots** (< pixel High Spatial Resolution (HSR))
- **Diversity of practices** (e.g. intercropping) **and crop calendars**
- **High cloud cover**

➔ **Difficulties of remote sensing for the characterization of complex systems (e.g. smallholder farming)**

[Inglada *et al.* 2015, Lebourgeois *et al.* 2017]

Objective

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Develop a new approach to **process satellite time series** based on a **modelling platform** integrating **constraints related to human-environment interaction** to improve the characterization of smallholder agriculture areas

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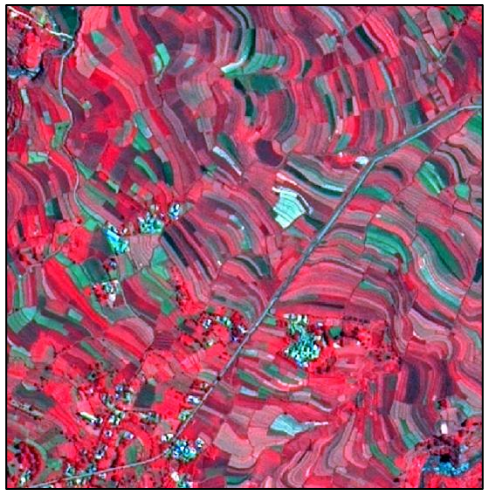
Investigate the complementarity of Remote Sensing and Spatio-Temporal Modelling approaches

- How can **spatio-temporal modelling help to transform remote sensing** data into more reliable thematic products?
- How can **remote sensing help to objectify the functioning of processes** as expressed by formalized knowledge in models?

Data

VHSR :
Structure



SPOT6/7 (1.5m), Pléiades (0.5m)

Data

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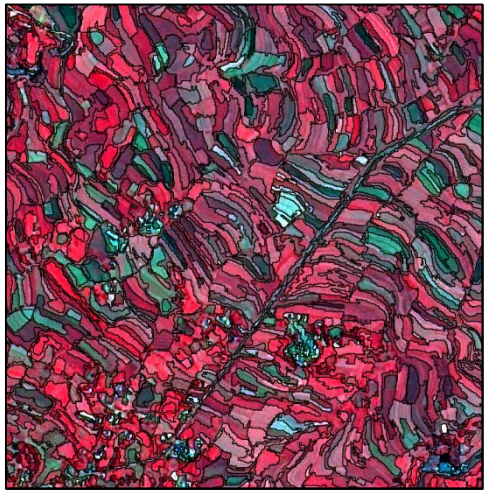

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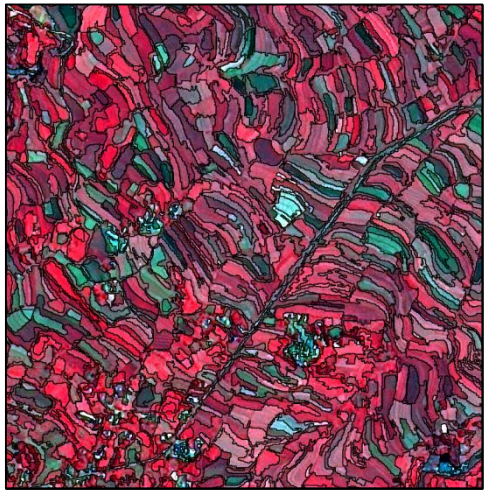

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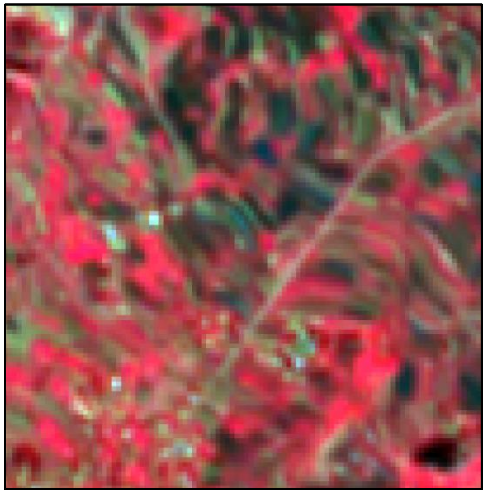
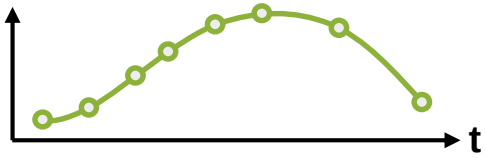
Time series :
Functioning



Sentinel 2 (10m), Landsat 8 (30m)



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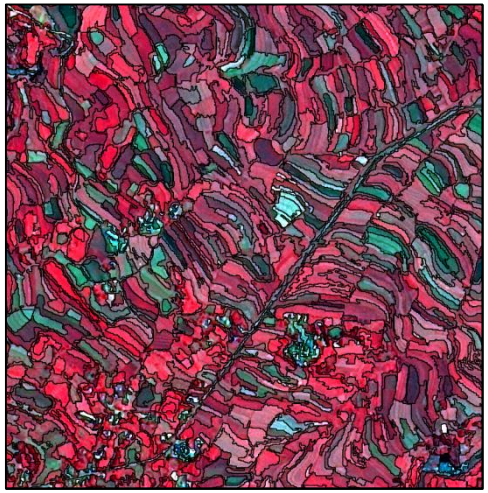

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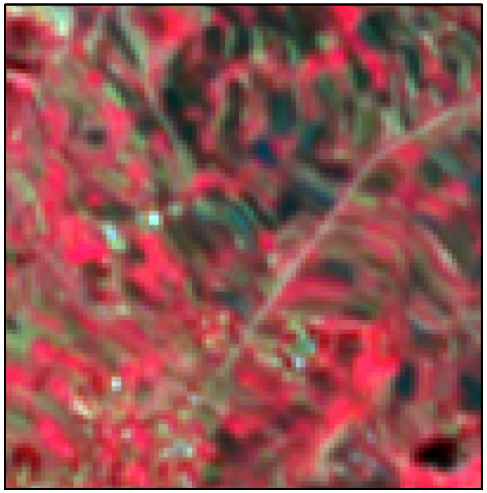

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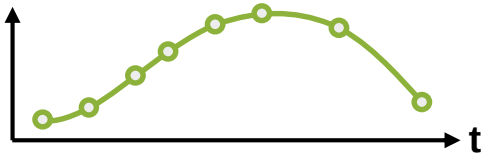
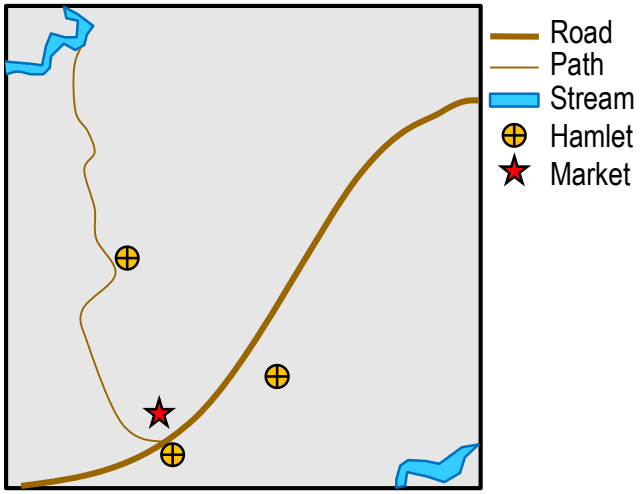
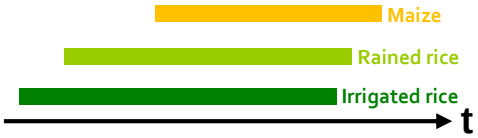


Formalized knowledge:
Spatio-temporal constraints



Strategies and agricultural practices

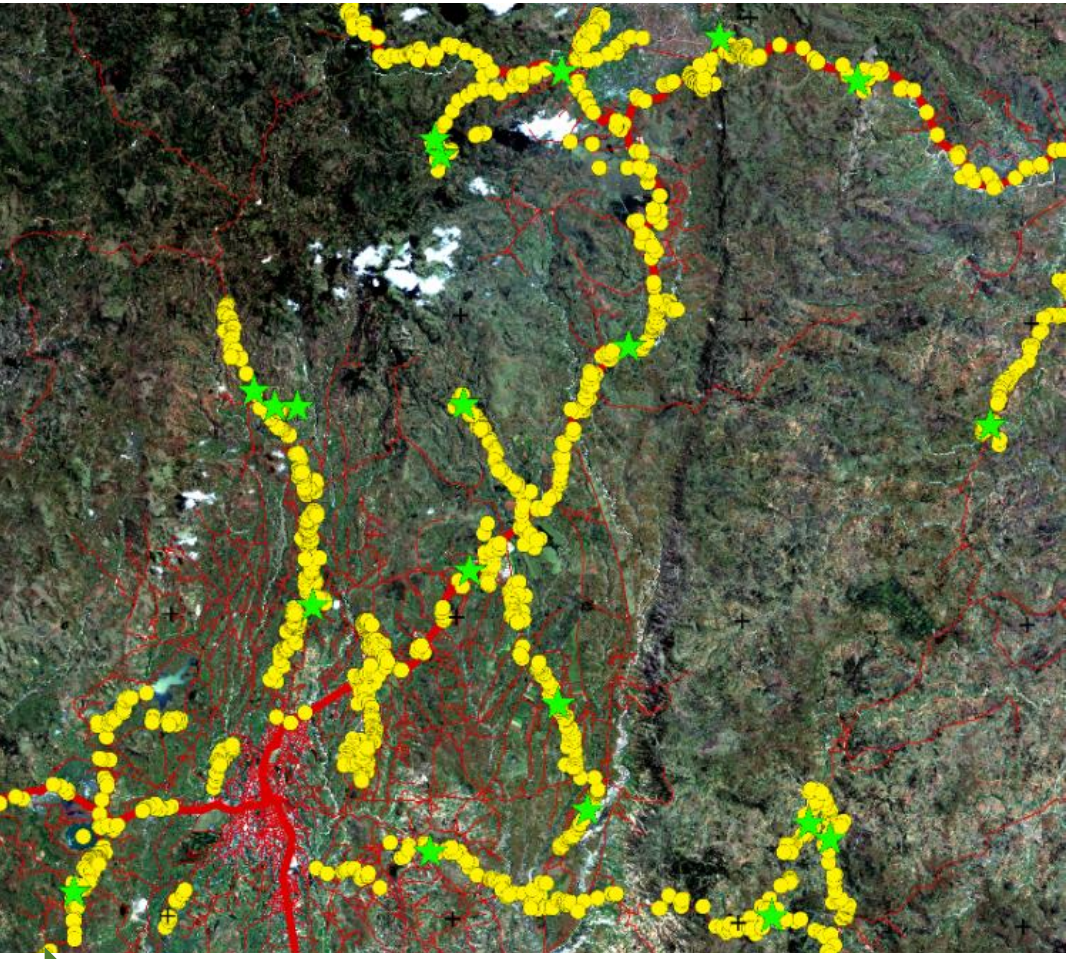


Land use data & surveys on ag. strategies

10

Land use data & surveys on ag. strategies

GPS land use surveys

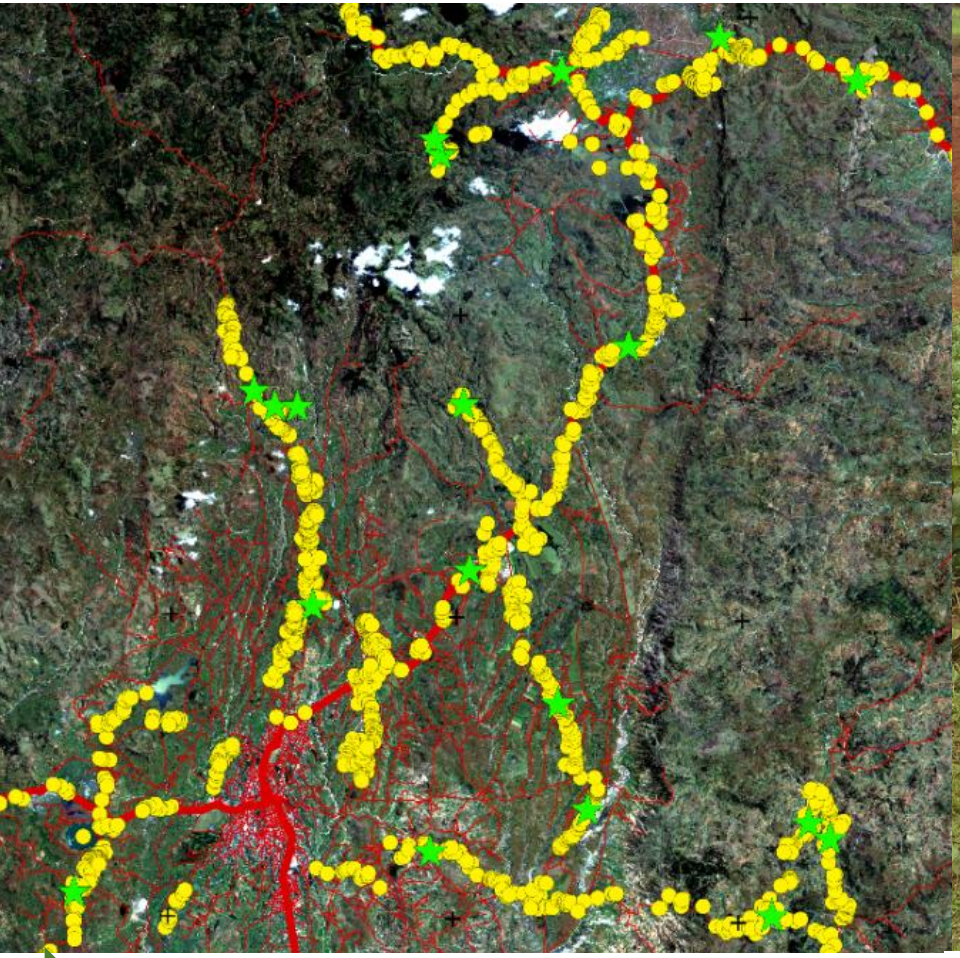


Build a ground truth database for learning and validation

Land use data & surveys on ag. strategies

GPS land use surveys

Interviews with rural development experts, farmers, scientists + literature



Build a ground truth database for learning and validation

Formalization into spatio-temporal rules expressing farmers' strategies

Method > Spatio-Temporal rules

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Selection of rules:

- Representative of the whole study area
- Recurrent in interviews
- Realistic (in agronomic terms)
- Applicable

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Market gardening →

R1: Good connection to markets
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R3: Distant to village < 300 m
R4 : …

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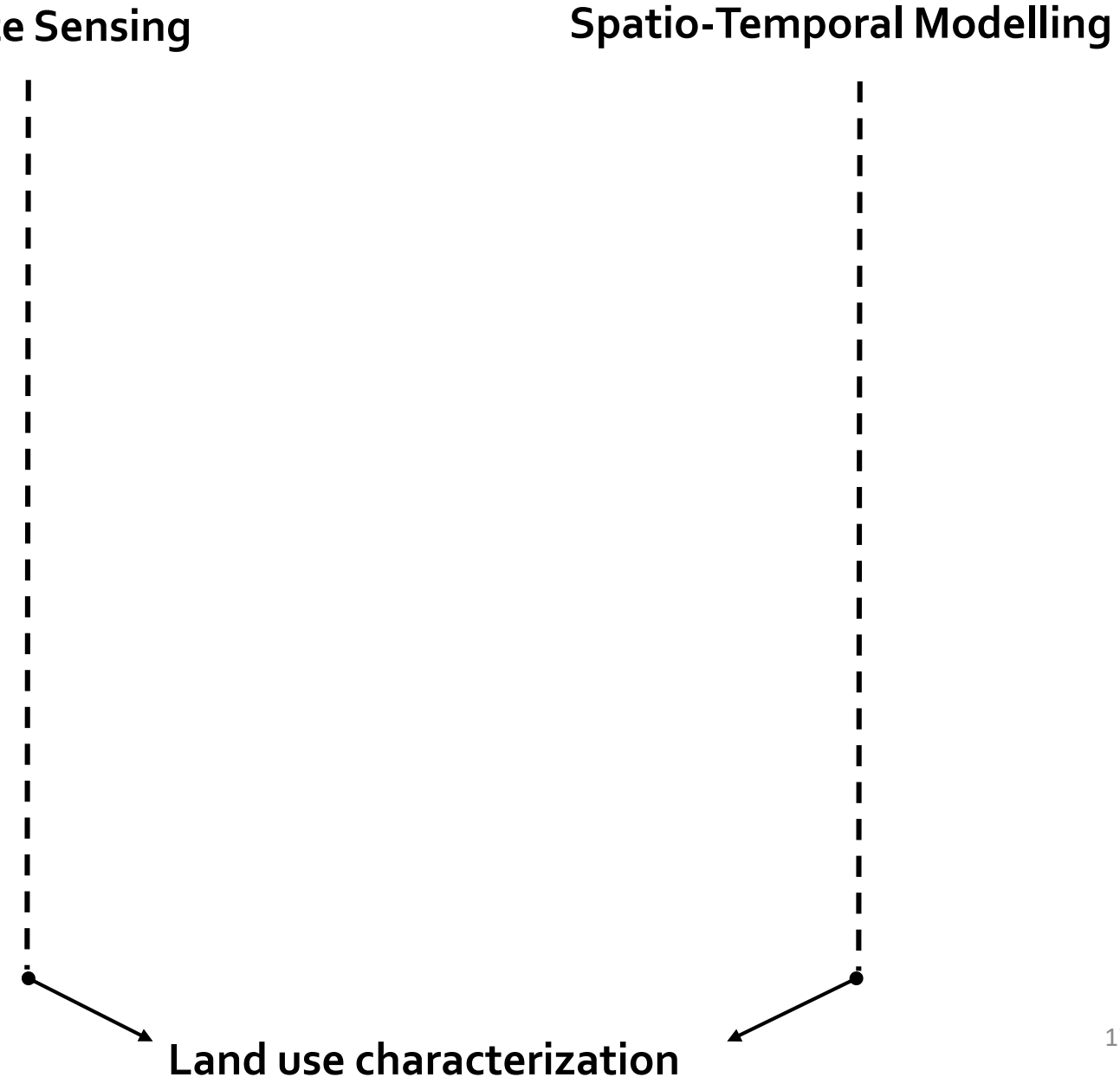
Irrigated rice →
R1: Irrigated lowlands
R2: < 150 m from a stream
R3: Growth 12/15-04/15
R4: …

Method


Remote Sensing
Spatio-Temporal Modelling
Land use characterization

Method > Remote Sensing

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OBIA

VHSR segmentation

(SPOT6 – 1.5m)

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Feature extraction

from time series

to build a learning database

Based on training samples

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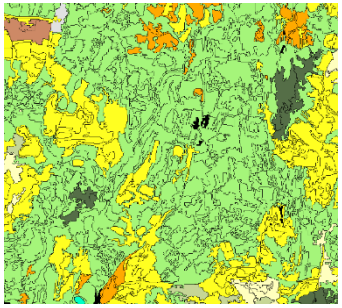

Classification

+ class membership probabilities

with **Random Forest** algorithm

CMP1 [**0.30** ; **0.40** ; **0.20** ; **0.10**]

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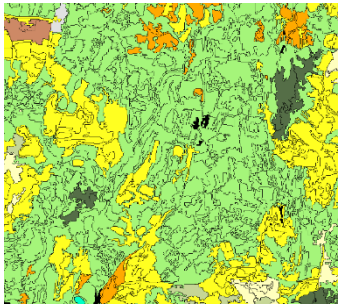

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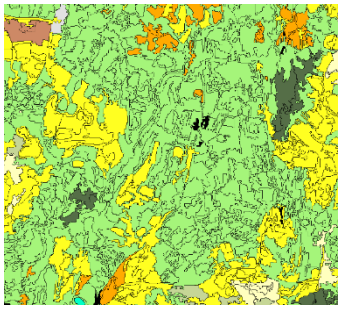

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Spatio-Temporal Modelling

Definition of spatio-temporal rules

Market Gardening

R1: …

R2 : …

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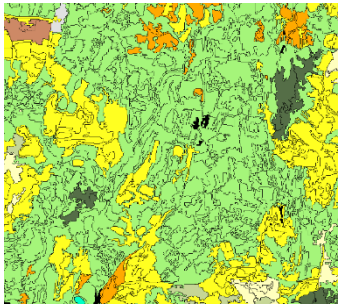

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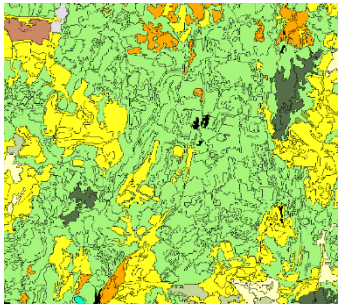

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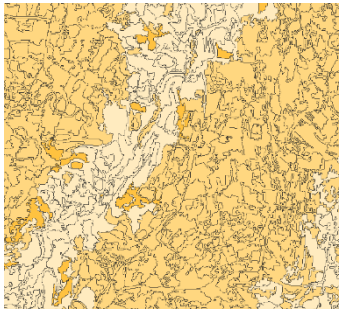
Implementation

Map of probability



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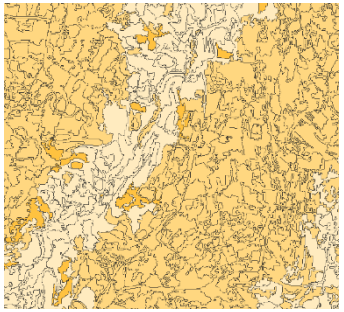

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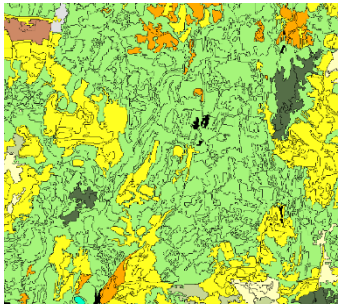

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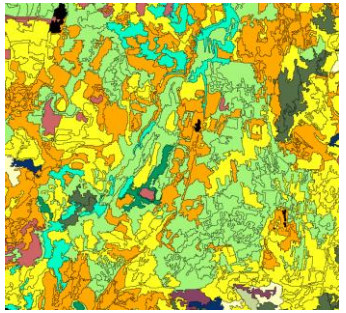
Redefinition of class membership probabilities



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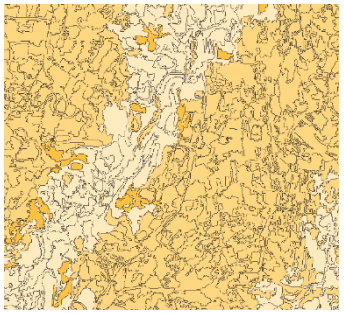
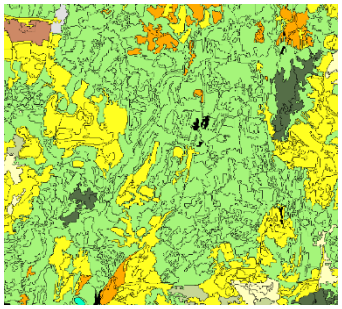


3



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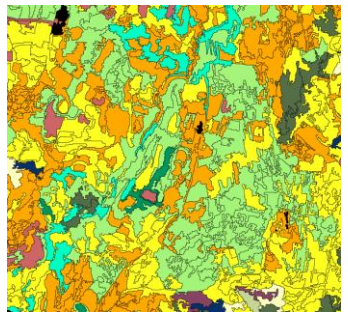
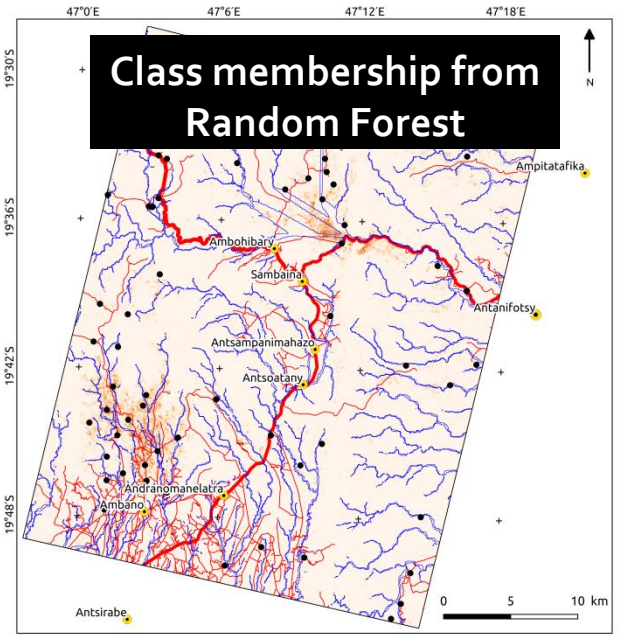
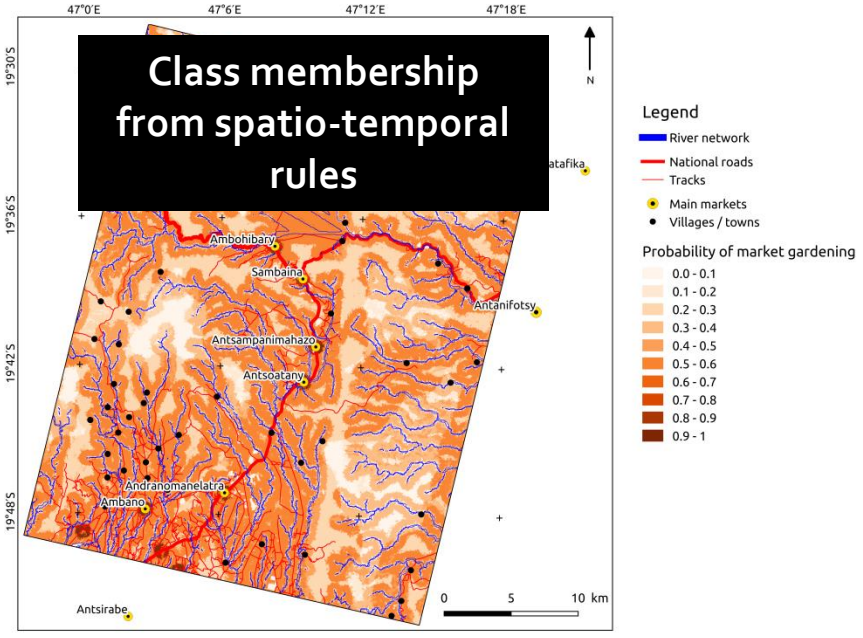


CMP1 [0.30 ; 0.40 ; 0.20 ; 0.10] → CMP2 [0.15 ; 0.20 ; 0.65 ; 0.00]

RS & ST Modelling





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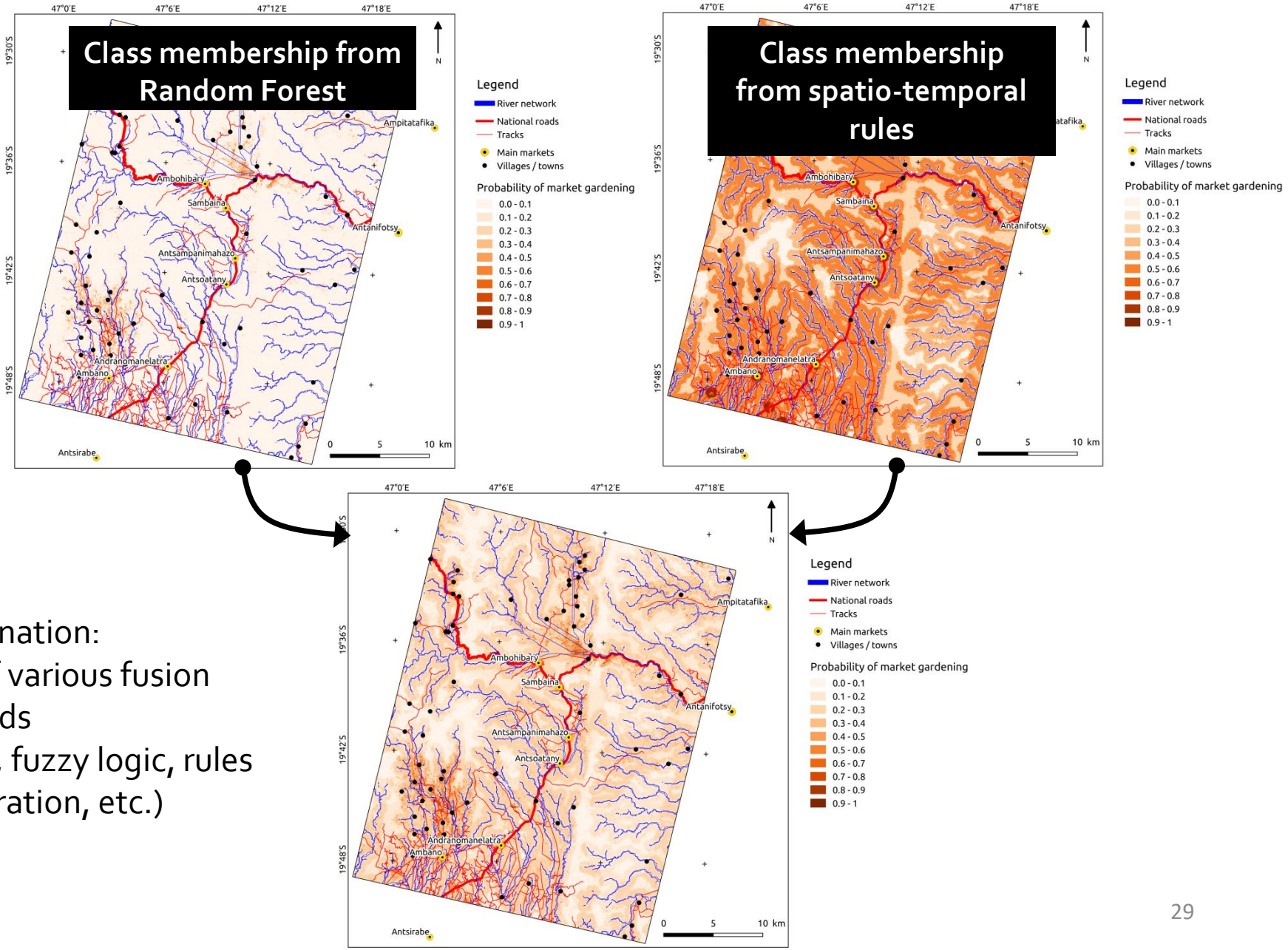
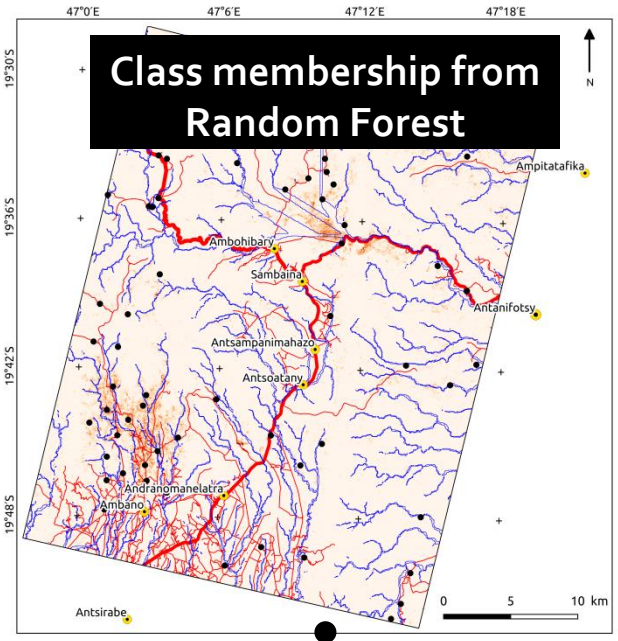
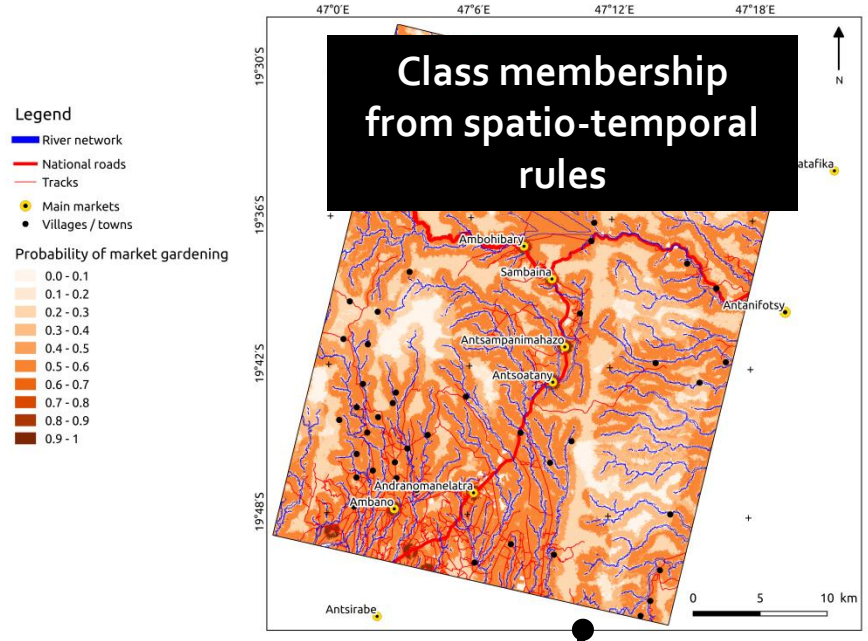
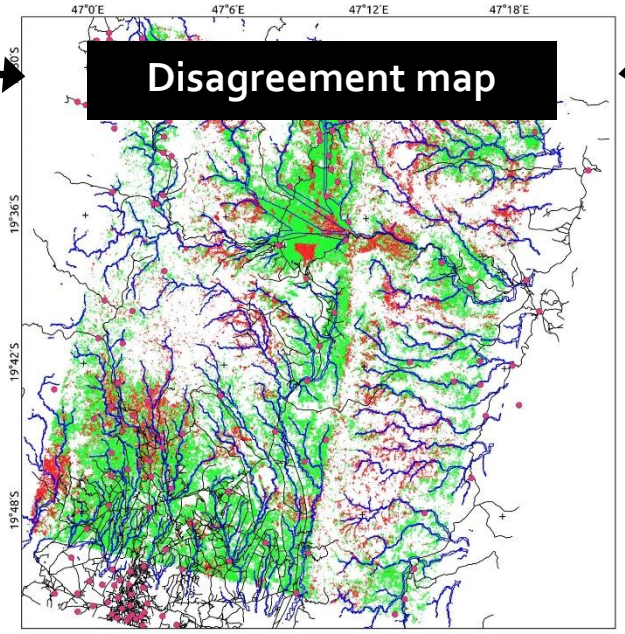


Combination:
Test of various fusion methods
(mean, fuzzy logic, rules ponderation, etc.)

RS & ST Modelling







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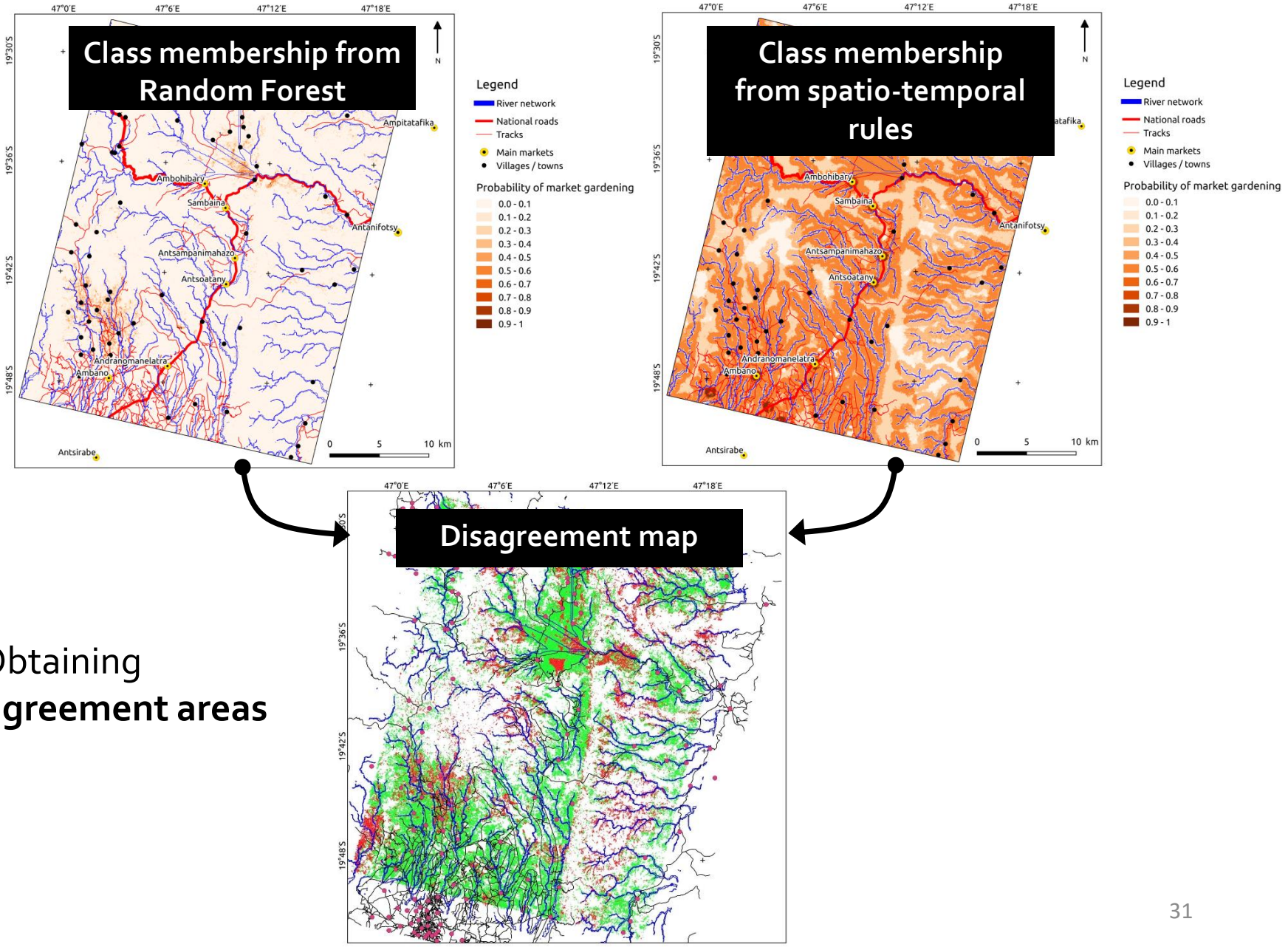
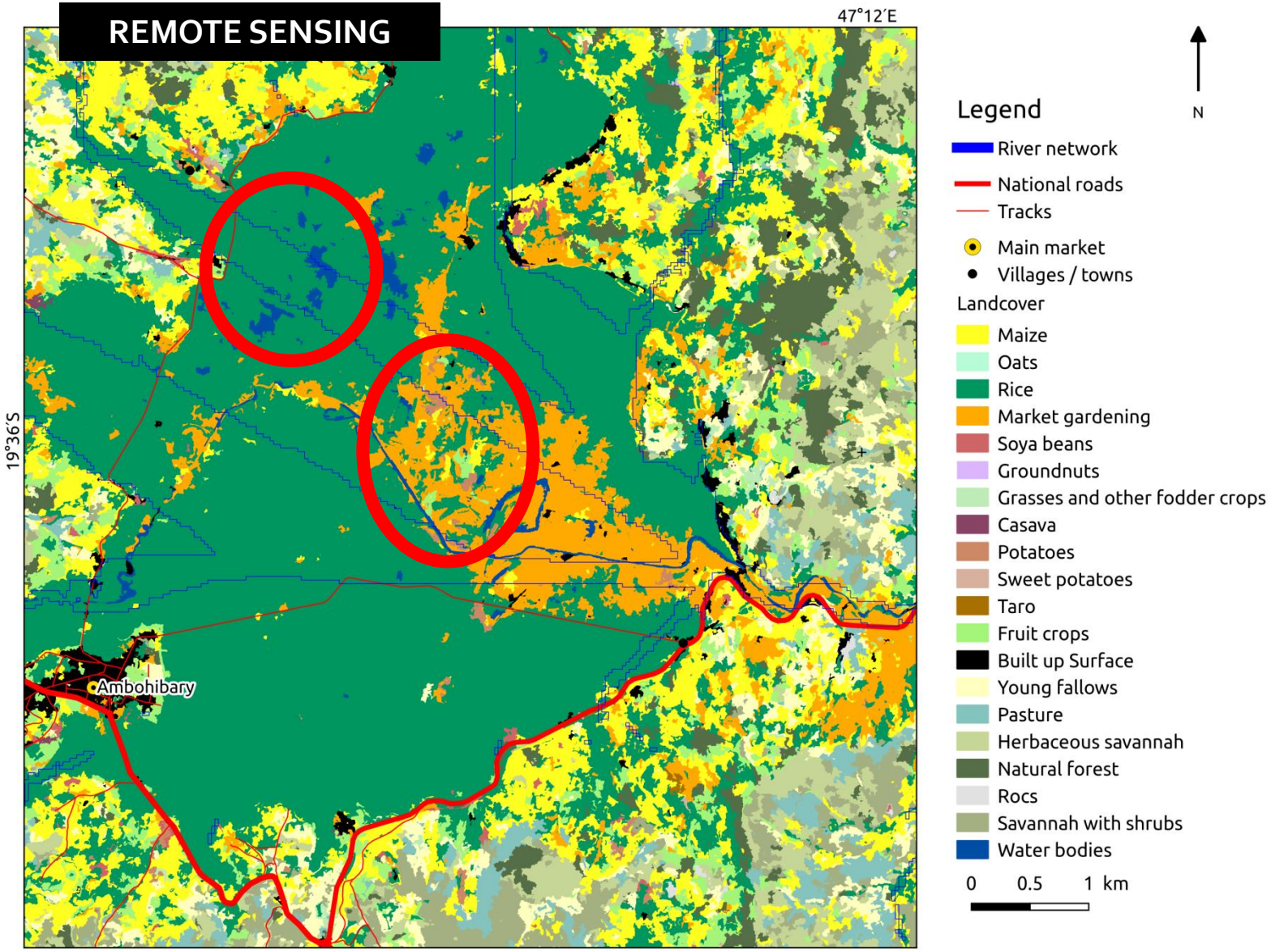
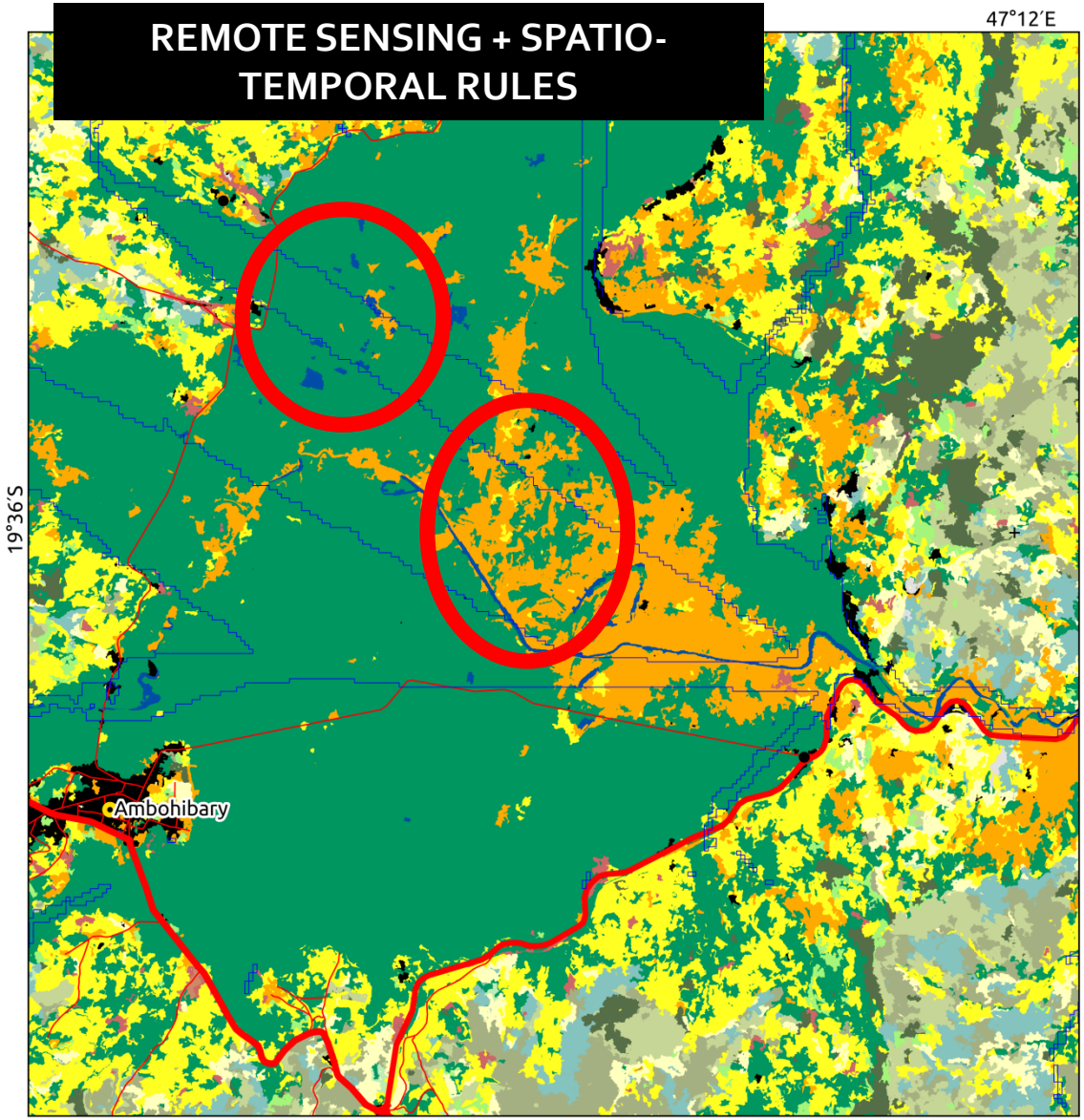


→ Obtaining **disagreement areas**

Maps


REMOTE SENSING
47°12′E
19°36′S
Ambohibary
Legend
N
River network
National roads
Tracks
Main market
Villages / towns
Landcover
Maize
Oats
Rice
Market gardening
Soya beans
Groundnuts
Grasses and other fodder crops
Casava
Potatoes
Sweet potatoes
Taro
Fruit crops
Built up Surface
Young fallows
Pasture
Herbaceous savannah
Natural forest
Rocs
Savannah with shrubs
Water bodies
0 0.5 1 km

Maps



Validation with field experts

Conclusion

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Relevance of the approach

→ Original approach **combining remote sensing** and **modelling** with knowledge from the **human and social sciences,** providing more **agriculturally consistent maps**.

→ Helps to improve the **understanding of processes** and the characterization of a complex system.

→ Generic framework which could be adapted to other thematic applications (e.g. biodiversity).

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What's next ?

→ Test of the approach on a more complete ground and satellite dataset + statistic validation of the classification from GT.

→ Sensitivity analysis of our model to spatiotemporal rules.

Bibliography

Inglada J., Arias M., Tardy B., Hagolle O., Valero S., Morin D., Dedieu G., Sepulcre G., Bontemps S., Defourny P., Koetz B., **2015**. Assessment of an Operational System for Crop Type Map Production Using High Temporal and Spatial Resolution Satellite Optical Imagery. *Remote Sensing*, *7*, 12356-12379.

Lebourgeois V., Dupuy S., Vintrou É., Ameline M., Butler, S., Bégué, A., **2017**. A Combined Random Forest and OBIA Classification Scheme for Mapping Smallholder Agriculture at Different Nomenclature Levels Using Multisource Data (Simulated Sentinel-2 Time Series, VHRS and DEM). *Remote Sensing*, *9*, 259.

Thank you for listening

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